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RESEARCH PAPER

Evaluating Indigenous Practices for Petai (*Parkia speciosa* Hassk.) Seed Germination: The Effect of Seed Shelling and Seed Cutting on Germination, Growth, and Survival

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Abstract *Parkia speciosa* Hassk. (petai, pete, sator, and stink bean) is a medium to large tree native to Southeast Asia with various medicinal, wood, and shade tree uses. Its seed is an important component of Indonesian, Malaysian, and Thai cuisines. Petai is a common component of smallholder tree gardens throughout Indonesia. Indigenous propagation practices for this species are removal of the seed coat, cutting off ¼ to ½ of the seed, or both, before sowing in prepared beds or containers. These practices are thought by farmers to accelerate seed germination and improve seedling growth. Seed cutting is also practiced to retain part of the seed for household consumption. A research trial was implemented to document the effect of seed shelling and seed cutting on seed germination, seedling growth, and seedling survival. Results indicate that both treatments accelerate—but do not increase—seed germination. Nine days after sowing, the treatments increased germination by 27–32% over the controls; the combination of the treatments increased germination by up to 70%. However, by 35 days all treatments and combinations achieved 100% germination. Seed cutting had a negative effect on seedling diameter and height growth. The combination of no shelling and ½ cutting indicated higher seedling mortality over the study period. The findings support the use of the indigenous seed shelling practice but suggest discontinuation of seed cutting practices.

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Introduction

Parkia speciosa Hassk. in the Leguminosae family, Mimosoideae subfamily, attains a height of 15–30 m and diameter of 50–100 cm, and grows at elevations of up to 1,500 m, with best performance from 500 to 1,000 m. The species is native to Indonesia, Thailand, Malaysia, Brunei, and the Philippines. Its common names include petai or pete in Indonesia and Malaysia and sator in Thailand (Wiradinata and Bamroongrugsa 1994). In English petai is called *stink bean* because of the pungent aroma and taste of its seed, which is an important component of Indonesian, Malaysian, and Thai cuisines.

On average, per 100 g petai seed contains 71 g water, 11 g carbohydrates, 8 g protein, 8 g fat, 76 mg Ca, 83 mg P, 1 mg Fe, 724 IU vitamin A, 0.1 mg vitamin B_1, 0.01 mg vitamin B_2, 1 mg niacin, and 6 mg vitamin C (Wiradinata and Bamroongrugsa 1994). There is a high market demand for petai seed as a food condiment. In a market survey conducted by Fujita (1988) petai was found in every Indonesian and Malaysian market visited. Petai has medicinal uses and its wood is used to make furniture, boxes, and other wooden objects (Leaving and de Foresta 1991; Wiradinata and Bamroongrugsa 1994). It is planted as a shade tree for coffee, tea, and other crops to provide an additional source of income for the enterprise or workers.

Parkia speciosa has been identified as a priority species for research and development in Indonesia, Malaysia, and Thailand (Kaomini and Gintings 1999; Ab. Rasip et al. 1999; Gunasena and Roshetko 2000). In Indonesia, it is a common component of smallholder tree-based systems in Java, Sumatra, and West Kalimantan (Otsama and Sumantri 1999; Penot 1999; Roshetko et al. 2002; Manurung et al. 2005; Tarigan et al. 2007), and also found in smallholder systems in Nusa Tenggara (Stoney 1992) and Sulawesi.

Farmers in Nanggung sub-district, Bogor District, West Java are representative of their peers in many parts of Indonesia. They are smallholders living at or below the poverty line and cultivating less than 1 ha of land. On average Nanggung farmers have access to 0.3 ha of irrigated rice land and 0.5 ha of upland tree gardens (kebuns). Kebuns are primarily multi-species systems managed under traditional non-intensive practices (Roshetko et al. 2004). In Nanggung, petai is the ninth most common farm tree comprising 2.2% of all trees (Manurung et al. 2005); it is found in 47.2% of tree gardens and accounts for 10% of the non-timber income from tree gardens, 3% of agriculture income, and 1% of overall household income (Budidarsono et al. 2006).

In response to market forces the production of smallholder tree garden systems is becoming more commercially oriented (Roshetko et al. 2004). Farmers base tree garden species selection on the species' potential for generating income and producing goods for household use, particularly food (Manurung et al. 2005). Petai

is a well suited species choice for smallholders because it yields an important culinary condiment that has a high household and market demand. Farmers need to adopt nursery management practices that produce large, healthy seedlings in an efficient and effective manner. Besides using petai seedlings to enrich their tree gardens farmers also have opportunity to sell high quality seedlings to government and private customers (Roshetko et al. 2004).

The World Agroforestry Centre (ICRAF), Winrock International, and RMI (Indonesian Institute for Forest and Environment) implemented a technical support program in Nanngung to assist motivated farmers who were committed to improving their incomes by increasing the production and market access for their agroforestry products. The program and approach is described in Roshetko et al. (2007). Developing community nurseries and tree seedling propagation methods were a focus of the program.

Seed coat removal (shelling) and seed coat cutting (or nicking) are seed pre-treatments applied to overcome dormancy, accelerate germination, or both, by facilitating water imbibition by the seed. Nursery and seedling propagation manuals recommend these pre-treatments as efficient and effective management practices to achieve uniform seed germination and uniform seedling growth. Traditionally, Nanggung farmers propagate petai seedlings by removing the seed coat and cutting off ¼ to ½ of the seed before sowing in prepared beds or containers. To prevent damage to the embryo, seeds are cut opposite the micropyle. The main reason for cutting is to retain some of the seed for household consumption. Additionally, farmers believe removing the seed coat and cutting the seed accelerates seedling growth. Farmers' indigenous beliefs have never been tested or documented.

This paper reports research conducted to evaluate farmers' indigenous petai propagation practices. The objectives of the study were to document the effect of seed shelling and seed cutting on: (i) seed germination rate; (ii) seedling growth, and (iii) seedling survival. The hypothesis were that seed shelling and cutting would accelerate germination and initial seedling growth, but result in higher seedling mortality.

Research Method

A trial was established in a randomized factorial design with two factors—seed shelling at two levels, no shelling (K0) and shelling (K1)—and seed cutting at three levels—no cutting (P0), ¼ of the seed removed (P1), and ½ of the seed removed (P2). There were six treatment combinations: K0P0, K0P1, K0P2, K1P0, K1P1, and K1P2. The K0P0 (shelling, no cutting) treatment served as the control. Four replications of each treatment were established for a total of 24 trial units. Each trial unit was composed of 10 seed.

Seed was collected from a healthy 20-year-old mother tree of superior phenotypic characteristics in Nanggung, following the procedure recommended by Mulawarman et al. (2003). Seed were sorted and selected for a uniform weight of 2.5–3.0 g per seed. Before sowing, seeds were coated with fungicide and insecticide by submergence for a few minutes. To replicate actual conditions, the trial was

conducted in a farmer group nursery in Nanggung at elevation of 300 m. The nursery soil medium used was equal parts forest soil, compost, and sand.

Germination data were collected 9 days after seed sowing. Data collection for other parameters (seedling height, diameter, number of leafs, size of leaf, and seedling mortality) commenced 35 days after seed sowing. Measurements of these parameters continued over 10 2-week intervals, with the last measurement occurring 161 days after seed sowing. Analysis of variance (ANOVA) with a 5% level of significance and least significant differences (LSD) were used to determine the effect of treatments.

Experimental Findings

Germination Acceleration

There were significant differences in both treatment effects and their interactions. Nine days after sowing, 30% of shelled seed (K1) germinated while only 3% of unshelled (K0) seeds germinated; 7.5% of uncut seeds (P0) germinated, 2.5% of ¼ cutting treatment (P1), and 40% of the ½ cutting treatment (P2). Differences between the shelling treatments and between ½ cutting and other cutting treatments were significant. The differences between shelling and ½ cutting treatments were not significant. The shelling and ½ cutting (K1P2) combination had a significantly higher germination rate (70%) compared to all other combinations which had germination rates of only 0–15%. Germination data for treatments and for interactions are presented in Table 1.

Seedling Growth

Seed shelling had no significant effect on diameter or height growth. Seed cutting reduced growth throughout the study period. Half cutting of seeds had a significant negative impact on diameter growth and height growth, by an average of 21.3–28.2%, respectively compared to no cutting. Quarter cutting of seeds had a significant negative impact on height growth by an average of 11.9% compared to no cutting. Differences in height growth between all three cutting treatments and diameters growth between ½ cut and the other two cutting treatments were

Table 1 Seed germination rate for each treatment and each interaction

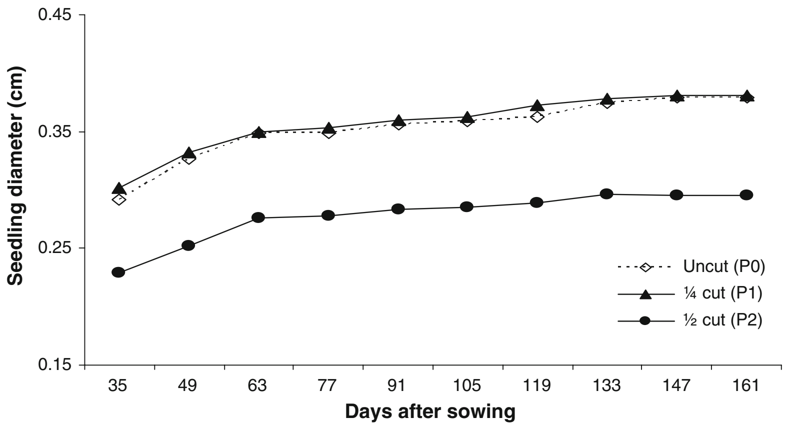
Statistic	Shelling		Cutting			Interactions					
	K0	K1	P0	P1	P2	K0P0	K0P1	K0P2	K1P0	K1P1	K1P2
Seed germination rate (%)	3.0	30.0	7.5	2.5	40.0	0	0	10.0	15.0	5.0	70.0
Probability (by *F* test)	<0.001		<0.001			<0.001					
Least significant difference	6.39		7.83			11.07					

significant through the study period. Figures 1 and 2 depict seedling diameter and height growth over time.

Half cutting of seeds significantly reduced the number of leaves per seedling, by an average of 15.6% compared to the no cutting treatment, throughout the study period (Fig. 3). Quarter cutting of seeds increased the number of leaves per seedling, by an average of 6.5% compared to the no cutting treatment from the third observations (63 days after sowing) through the end of the study period (Fig. 3). Shelling had a significant positive effect on the number of leaves per seedling by 6.3% compared to the no shelling treatment, but only at the first observation (35 days after sowing), and differences thereafter were not significant. There were no significant effects on growth parameters from any of the interactions.

Seedling Mortality

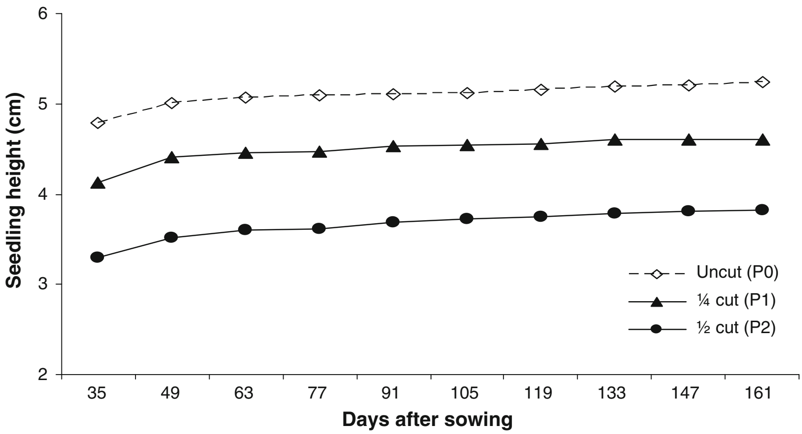
There was no direct effect on seedling mortality by either treatments or their interactions. However, the combination of no shelling-½ cutting (K0P2) showed a trend towards higher mortality over the 161 day period. Seedling survival was 100% 35 days after seed sowing. At the last observation (161 days after sowing) mortality varied from 17.5% to 37.5% (Table 2).



Treatment	Days after sowing									
	35	**49**	**63**	**77**	**91**	**105**	**119**	**133**	**147**	**161**
Uncut (P0)	0.292	0.327	0.349	0.349	0.356	0.359	0.363	0.375	0.379	0.379
¼ cut (P1)	0.302	0.332	0.35	0.353	0.36	0.363	0.373	0.378	0.381	0.381
½ cut (P2)	0.229	0.252	0.276	0.278	0.283	0.285	0.289	0.296	0.295	0.295
F prob.	0.009	0.008	0.022	0.022	0.019	0.021	0.016	0.019	0.012	0.012
SEM[a]	0.026	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.033	0.039
LSD[a]	0.051	0.056	0.059	0.059	0.061	0.061	0.062	0.064	0.065	0.065

a. SEM is the standard error of the mean, and LSD is the least significant difference.

Fig. 1 Seedling diameter growth (cm) for cutting treatments over the 10 2-week observation periods



Treatment	Days after sowing									
	35	**49**	**63**	**77**	**91**	**105**	**119**	**133**	**147**	**161**
Uncut (P0)	4.79	5.01	5.07	5.09	5.11	5.12	5.15	5.19	5.21	5.24
¼ cut (P1)	4.13	4.41	4.46	4.47	4.53	4.55	4.56	4.6	4.6	4.61
½ cut (P2)	3.3	3.52	3.6	3.61	3.69	3.72	3.75	3.79	3.81	3.82
F prob.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SEM	0.115	0.122	0.159	0.180	0.189	0.222	0.238	0.304	0.312	0.325
LSD	0.227	0.196	0.255	0.289	0.303	0.357	0.383	0.49	0.502	0.523

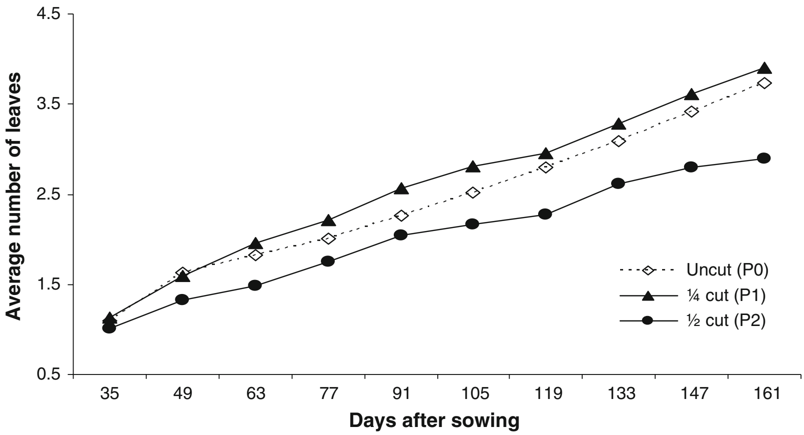
Fig. 2 Seedling height growth (cm) for cutting treatments over the 10 2-week observation periods

Discussion

Seed shelling and seed coat cutting are seed pre-treatments used in small to commercial-scale tree seedling production enterprises to accelerate germination and achieve uniform seedling growth. Seed coat cutting is usually limited to scarification of the outer surface of seeds with hard coats. Shelling, the removal of the seed coat, effectively makes seed coat cutting superfluous.

In this study the indigenous practices of seed shelling, seed cutting, and their interaction all accelerated germination compared to no seed treatment. Nine days after sowing, germination was 30% for shelling, 40% for ½ cutting, and 70% for their combination, compared to 3% for no shelling, 7.5% for no cutting, and zero for some no shelling–cutting combinations. By 35 days after sowing all treatments and their interactions achieved 100% germination as indicated by 0% mortality during the first observation (Table 2). These results indicate that seed shelling and cutting accelerates—but does not increase—seed germination.

The seed pre-treatment effects on seedling growth and mortality are less encouraging. Shelling showed no significant effect on seedling diameter or height growth. Shelling increased number of leaves per seedling 35 days after sowing, which is consistent with accelerated germination; however, this effect was no longer significant at subsequent observations. Half cutting reduced seedling diameter and height growth, while ¼ cutting reduced height growth, all throughout the study period. Half cutting reduced the number of leaves per seedling, while ¼ cutting



Treatment	Days after sowing									
	35	**49**	**63**	**77**	**91**	**105**	**119**	**133**	**147**	**161**
Uncut (P0)	1.09	1.63	1.83	2.01	2.26	2.52	2.80	3.09	3.42	3.73
¼ cut (P1)	1.13	1.59	1.96	2.21	2.57	2.81	2.96	3.28	3.61	3.90
½ cut (P2)	1.01	1.33	1.48	1.75	2.04	2.17	2.28	2.61	2.80	2.90
F prob.	<0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.002	0.013
SEM	0.041	0.080	0.113	0.138	0.171	0.204	0.231	0.278	0.309	0.339
LSD	0.080	0.158	0.113	0.272	0.337	0.401	0.456	0.547	0.609	0.667

Fig. 3 Average number of leaves for each cutting treatment over the 10 2-week observation periods

Table 2 Mortality rate (%) by interaction over the 10 2-week observation periods

Treatment	Days after seed sowing									
	35	49	63	77	91	105	119	133	147	161
K0P0	0	0	0	0	2.5	10	12.5	22.5	22.5	27.5
K0P1	0	2.5	5	5	7.5	7.5	7.5	15	17.5	17.5
K0P2	0	0	5	2.5	10	17.5	20	27.5	35	37.5
K1P0	0	0	0	2.5	2.5	5	7.5	15	17.5	20
K1P1	0	0	2.5	2.5	2.5	2.5	2.5	20	20	25
K1P2	0	0	7.5	10	10	12.5	12.5	22.5	22.5	22.5

increased the number of leaves per seedling. The positive effect may be a survival response to accelerate seedling development by seeds that lose ¼ of their endosperm, while seed that lose ½ their endosperm are unable to respond similarly. Neither treatment had an effect of seedling mortality; however, the no shelling-½ cutting combination showed higher mortality.

The experimental data and other observations indicate that stress caused by removing ¼ or ½ of the seed accelerated germination, but that the reduced endosperm was not sufficient to sustain seedling development, resulting in slower diameter and height growth compared to the seedlings in no cutting treatments.

Shelling also accelerated germination but without a negative effect on seedling growth, thus making cutting unnecessary. Farmers' justification of the cutting treatment as a desire to retain some of the seed for household consumption seems to be unjustified, because based on this study the amount retained for consumption would be only 0.7–1.5 g per seed. An equally successful approach would be to select the largest (uncut) seed for seedling propagation, and retain the other seeds for household consumption.

Conclusion

Testing of the indigenous methods used to propagate petai seedlings yielded mixed results. Seed shelling achieves uniform and accelerated germination but does not improve the overall germination rate or seedling growth. The policy implication is that seed shelling is desirable for small-scale nurseries where a limited number of petai seedling (10–100) might be produced. The shelling treatment is also appropriate for larger scale nurseries, but managers may want to consider ramifications on labour and time inputs. Seed cutting treatments also accelerate germination, but have a negative impact on seedling diameter and height growth and in combination with no shelling may increase seedling mortality. Furthermore, the use of seed shelling makes the limited advantages of seed cutting redundant. It is recommended that farmers discontinue the use seed cutting practices. Farmers concerns to retain part of the seeds for household use can be addressed by selecting the largest, best seed for propagation and using the rest for consumption.

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